Organization(s): **CFD Research Corporation; California Institute of Technology; University of California at Berkeley; and Abbott Labs**

Title: Mixed-Dimensionality VLSI-Type Configurable Simulation Tools for Virtual Prototyping Of Biomicrofluidic Devices And Integrated Systems

MTO **Composit CAD**

Duration of Effort: June 1998 - June 2001

Principal Investigator(s): Dr. Andrzej Przekwas
Phone: (256) 726-4815 /Email: ajp@cfdrc.com
Web: http://www.cfdrc.com

Objectives:

The project objective is to develop, validate and demonstrate several applications of a VLSI-type mixed-dimensionality software tool for system-level design of biomicrofluidic devices.

Major Accomplishments:

– This project established CFD-ACE+ software as a completely integrated multiphysics CAD environment for biofluidic microsystems. New tools, new ACE+ modules, and new capabilities have been developed. CFD-Micromesh has become a powerful fully automated 2D/3D layouts editor, automated mesher, and complete microsystem model builder run either interactively or from a Python script. ACE+ has new embedded FILAMENT capability to simulate multi-scale problems e.g. 1D fluidic networks embedded in 3D microsystem package. A new robust electrokinetics and bio-electrochemistry modules have been developed. Validation simulation results for several benchmark problems showed excellent accuracy and robustness. The new ACE-SPICE module enables circuit level modelin g of electrical, thermal, and fluidic devices and interconnects. ACE+ to SPICE link allow mixed-level simulations for example 3D high fidelity models can be linked with the network of filaments, and with electronic circuitry. ACE+ became industry only fully integrated device, component, and system level CAD tool for biofluidic microsystems.

DOD Impact:

– The new multiphysics CFD-ACE+ is being used at CFDRC, at several universities, and industry for defense related projects such as: Simbiosys, Simbad, BioFlips, MEMS, NeoCAD, MEMS Power, HERETIC, Palm Power, and others. CFDRC is working with DoD industry supporting SAIC, Honeywell, Motorola, Cepheid, Aclara and others. Several DoD agencies are or plan to evaluate the software including AFRL/RL, AFRL/WL, DTRA, AMCOM, NRL, IIDA and others.

Technology Transfer/Products:

– The new multiphysics CFD-ACE+ product has become an exceptional commercial success and has been commercialized worldwide. It is also used as research/educational tool by leading US universities. CFD-Micromesh has over 500 users worldwide. CFDRC is funding further enhancements in optimization, behavioral circuits, mixed level CAD, biophyscis, etc

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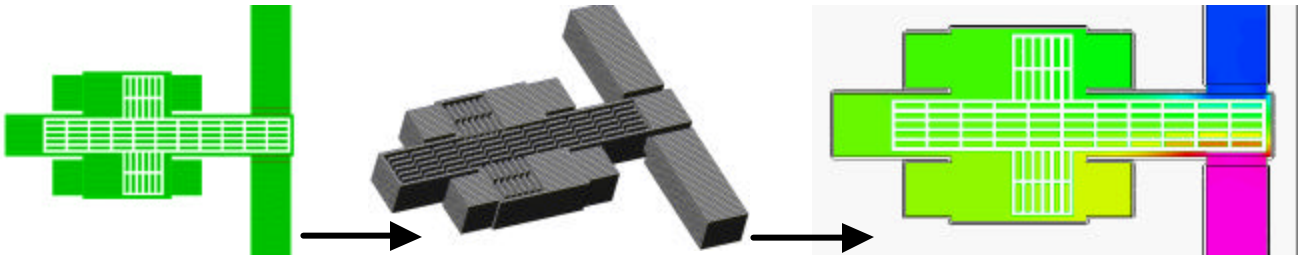
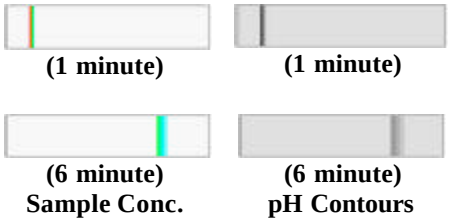


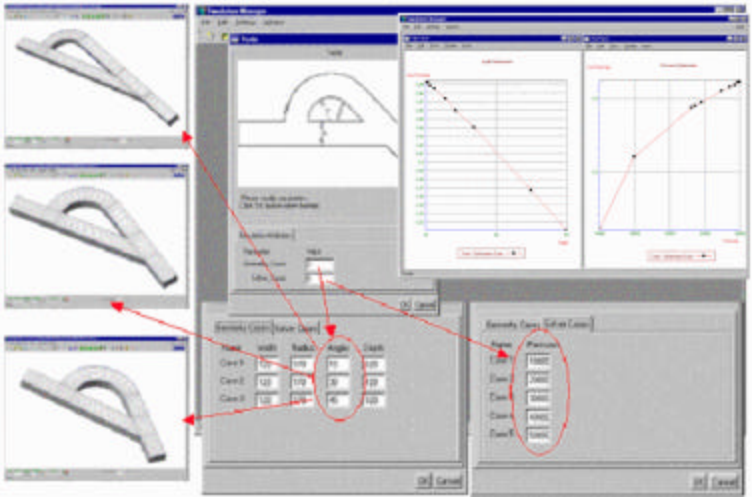
(a) 2-D Layout (b) "One-Click" Structured Grid (c) Pressure Drop Across Valve

Layout to Solid to Structured Mesh to Solution for a Microfluidic Check Valve Designed at UC Berkeley

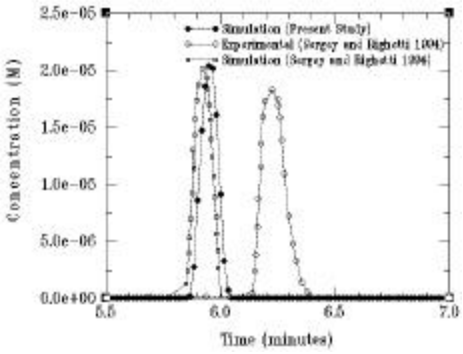
Filament Model-Based Microfluidic Simulation in a Biochip with Interconnecting Microchannels (Channel geometry/mesh in insert).



(a) Sample Transport and Ionization

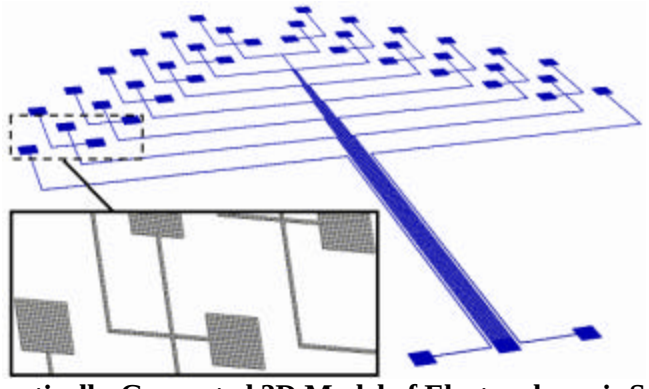


Numerical Optimization of Tesla Valve with CFD-ACE+ using Python script-based Simulation Manager

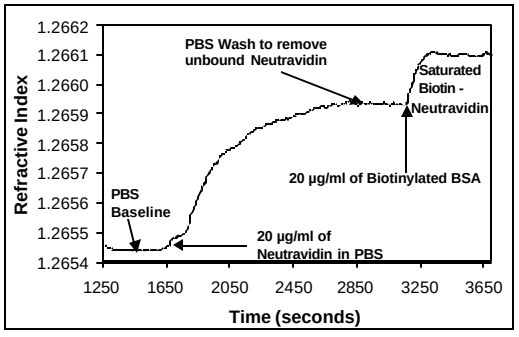


(b) Ionization Model Validation

Acid-Base Ionization Equilibrium Model



Automatically-Generated 3D Model of Electrophoresis System



Neutravidin-Biotin Binding Kinetics Measured with an Optical Biosensor